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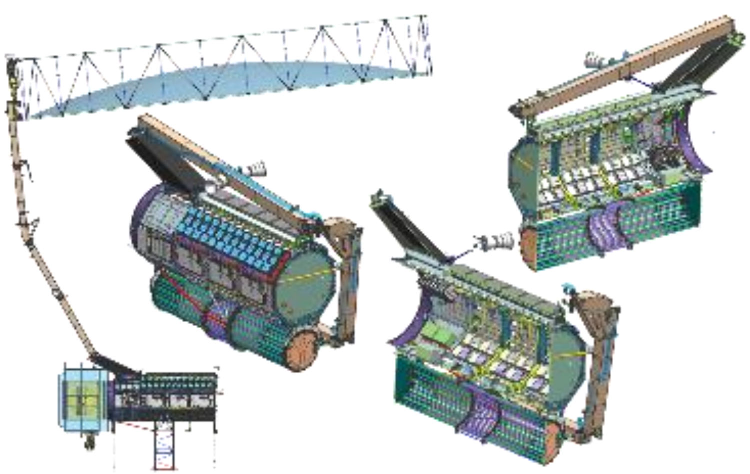


# An Overview of the NISAR L-band SAR System

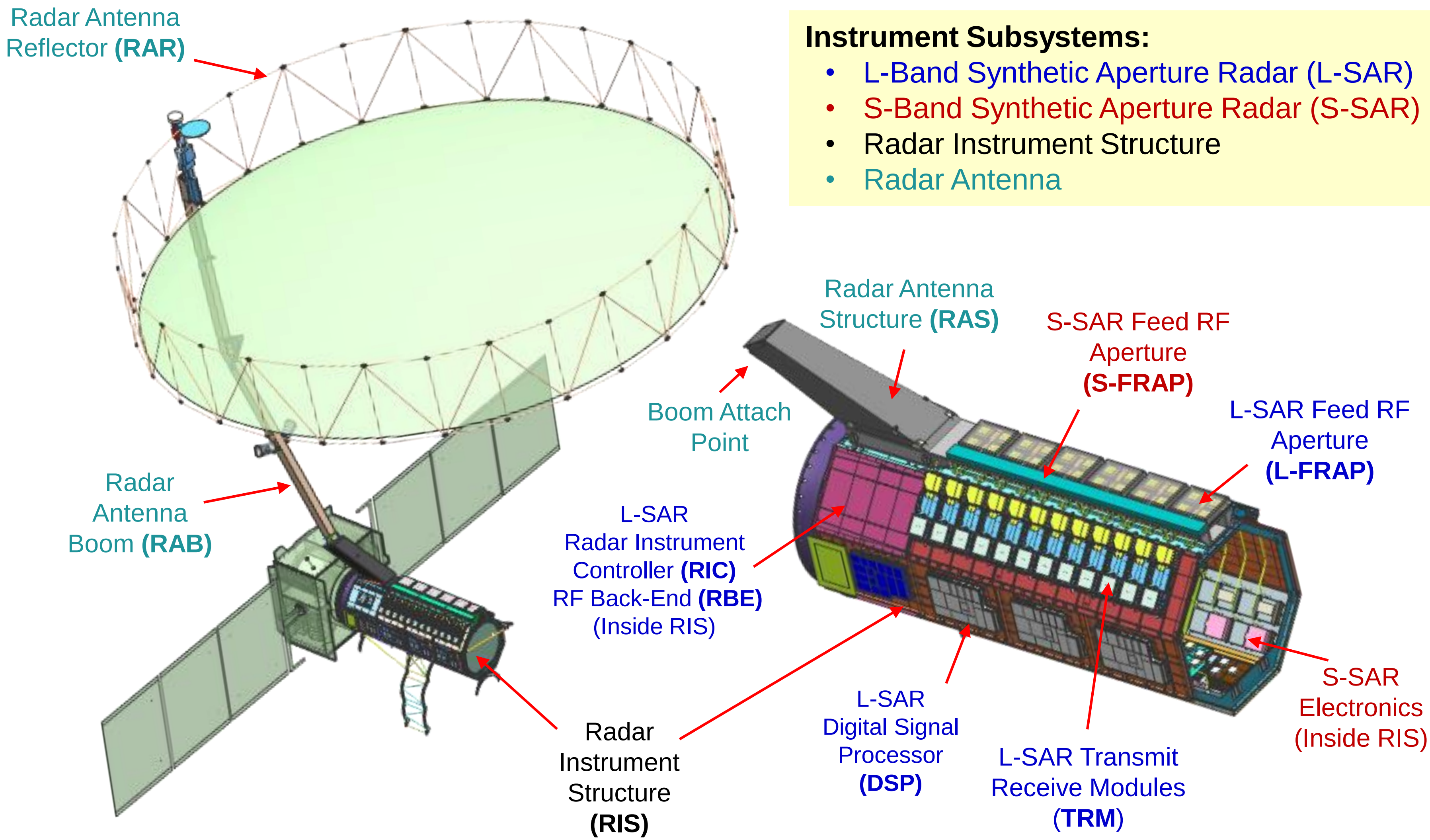

S. Shaffer, P. Rosen, W. Edelstein
G. Hamilton, Y. Kim

Jet Propulsion Laboratory
California Institute of Technology
Pasadena CA 91109, USA

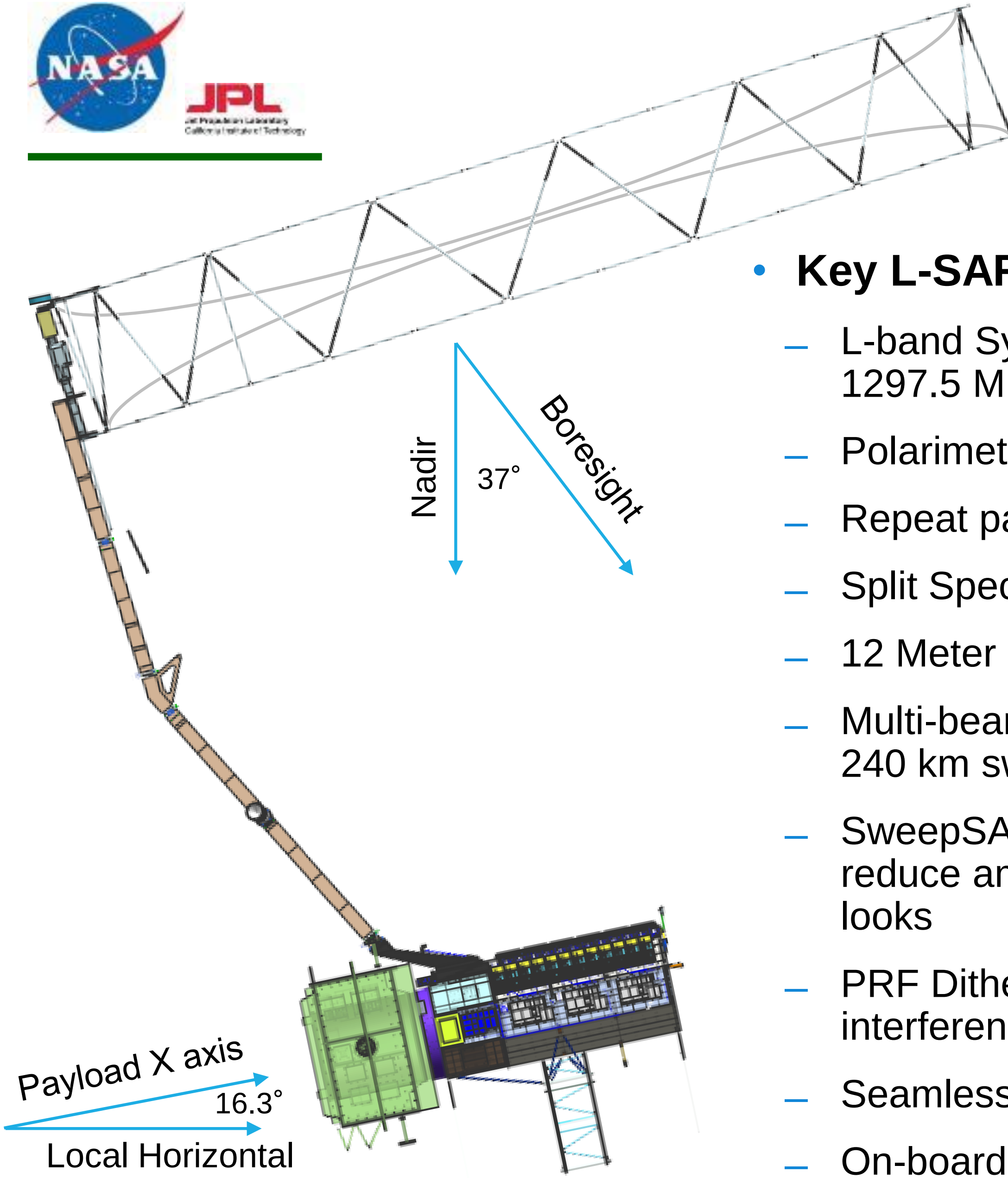
# Instrument Overview

**Instrument Subsystems:**

- L-Band Synthetic Aperture Radar (L-SAR)
- S-Band Synthetic Aperture Radar (S-SAR)
- Radar Instrument Structure
- Radar Antenna

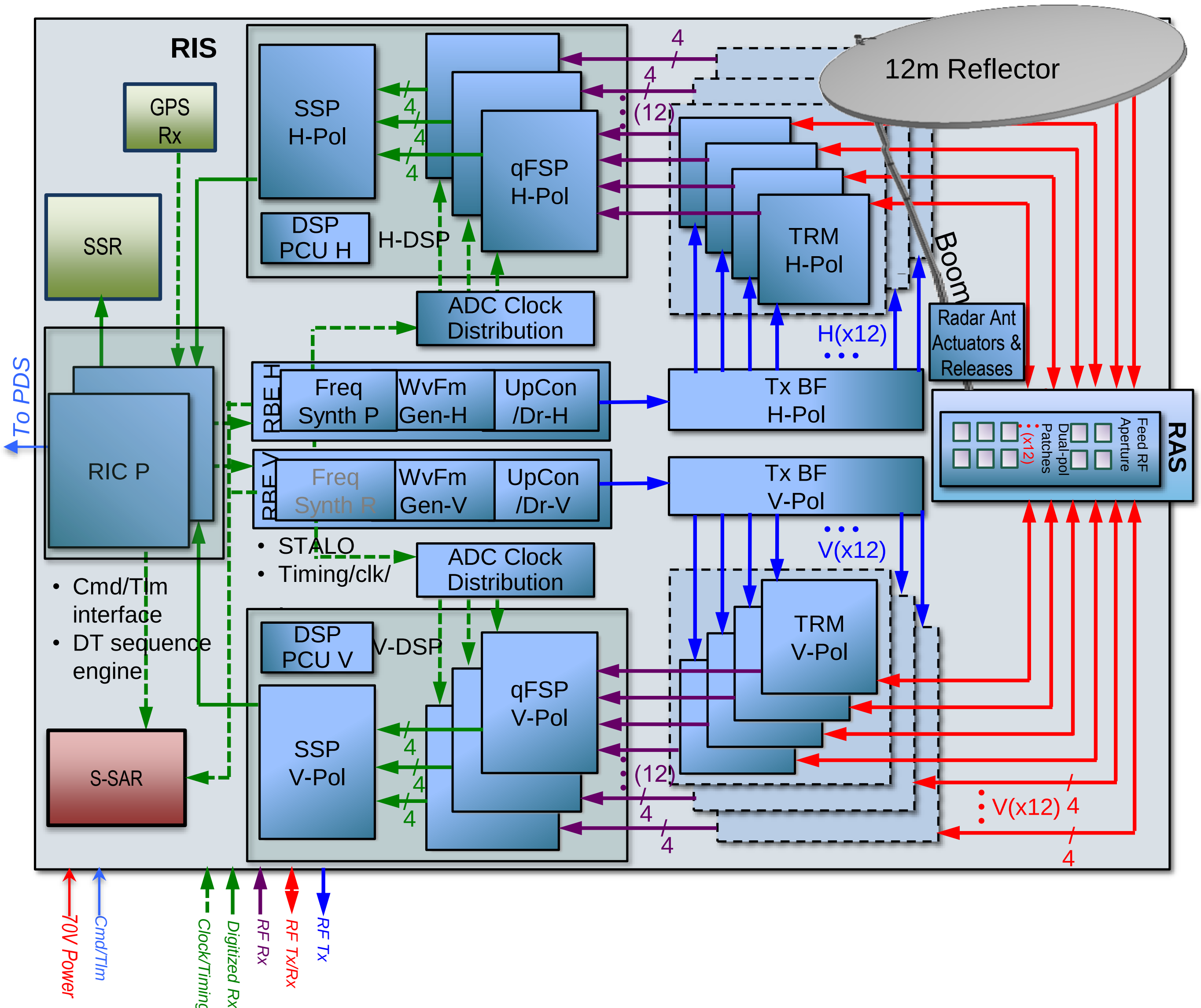


# L-SAR Instrument




- **Key L-SAR Instrument Features:**
  - L-band Synthetic Aperture Radar (1217.5 – 1297.5 MHz)
  - Polarimetry for classification and Biomass
  - Repeat pass interferometer for deformation
  - Split Spectrum for Ionosphere mitigation
  - 12 Meter deployable Mesh Reflector
  - Multi-beam Array fed Reflector to achieve a 240 km swath
  - SweepSAR timing and Digital Beam Forming to reduce ambiguities and preserve resolution / looks
  - PRF Dithering capability to fill transmit interference gaps when desired by science
  - Seamless mode transitions to minimize data loss
  - On-board filtering and data compression to reduce downlink

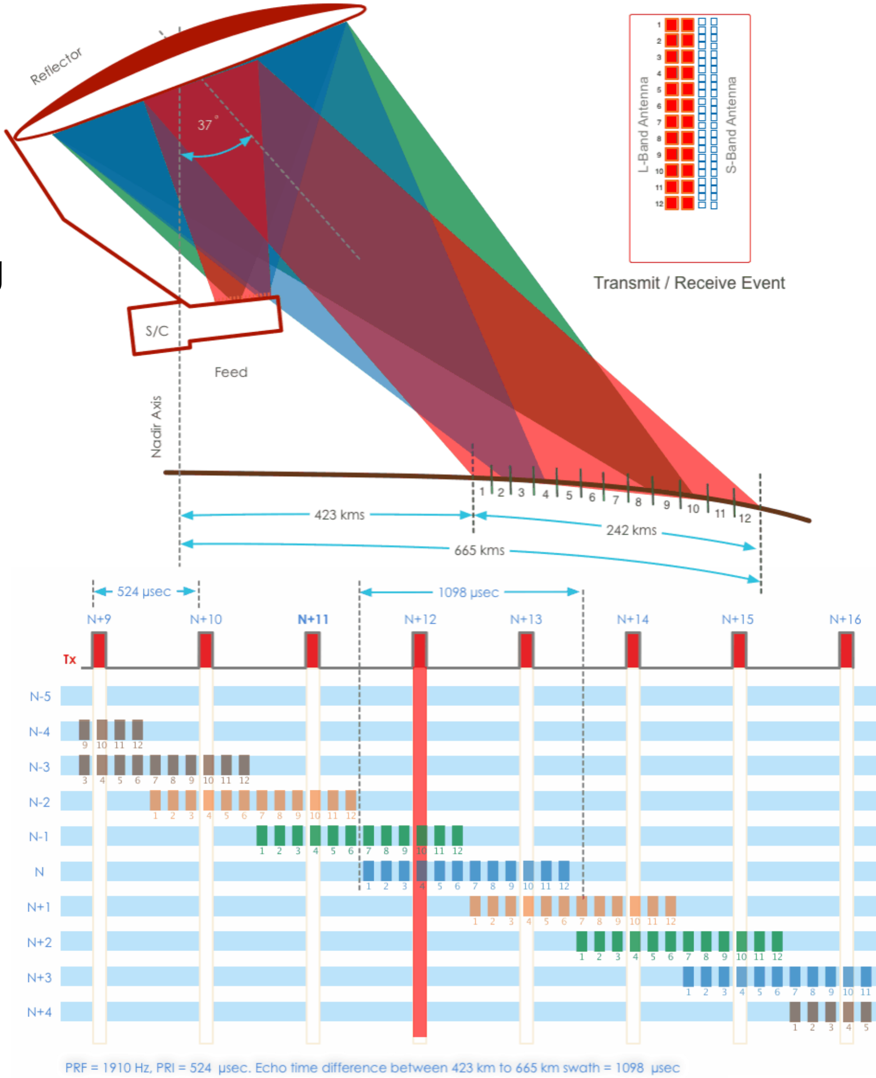
# L-SAR Instrument Architecture and Redundancy Strategy




- Combination of block redundancy, cross-strapping and graceful degradation
- Accepted Single Point Failures:
  - Radar Reflector and Boom: Impractical to make antenna redundant
  - Boom Deploy Electronics & Motors: Mass and cables over hinges increases technical risk / low likelihood of failure due to single use
  - RF Distribution Networks: Power dividers/coax are passive components

# L-SAR Measurement Technique

- **SweepSAR Basics**
  - On Transmit, the entire swath of interest is illuminate (red beam)
  - On Receive, the beam is steered in the range direction to follow the angle of the echo coming back to maximize the SNR of the signal and reject  range ambiguities
  - Allows echo to span more than 1 Inter Pulse Period (IPP)
- **Consequences**
  - 4 echoes can be simultaneously returning to the radar from 4 different angles in 4 different groups of antenna beams
  - Each echo needs to be sampled, filtered, Beam-formed, further filtered, and compressed
  - On-Board processing is not reversible – Requires on-board calibration before data is combined to achieve optimum performance



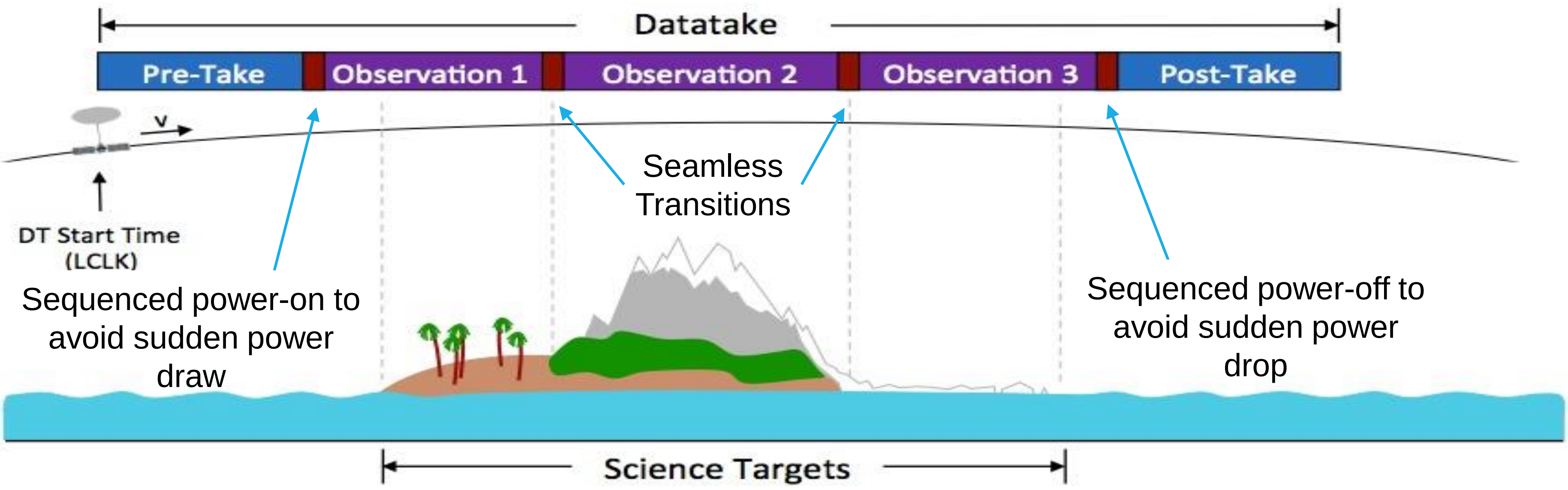

***Airborne demonstration of the SweepSAR Technique conducted in July, 2011***

# Commandable Radar Parameters

- To optimize the radar observation for a particular science or application objective, several parameters can be commanded in flight
  - **Polarization**: Single Pol (SP HH or VV), Dual Pol (DP HH/HV or VV/VH), Quad Pol (QP), Quasi-Quad Pol (QQP), Compact Pol (CP)
  - **Pulse Repetition Frequency** (PRF): typically 1500 to 1910 Hz (single pol PRF)
  - **Transmit Waveform**
    - Waveform consists of 1 or 2 pulses, followed by a calibration tone (Caltone)
    - Pulses and Caltones are selected from 128 pre-loaded options in the waveform generator
    - Baseline waveforms for single spectrum observations are: 5MHz/25us and 80 MHz/45us
    - Baseline waveforms for split spectrum are: 40MHz/40us+5MHz/5us and 20MHz/20us+5MHz/5us
    - Contingency waveforms exist to place the center frequencies at the opposite ends of the allocation
  - **Block Floating Point Quantization** (BFPQ): Nominal science to use 16 to 4 bit compression. Option for 16 to 8 and 16 to 3 bit compression during instrument commissioning and contingency operations
- Nominal science operations use 6 L-SAR modes
  - 6 are used for L-SAR only observations
  - 3 can be used in combination with S-SAR to form 6 joint modes

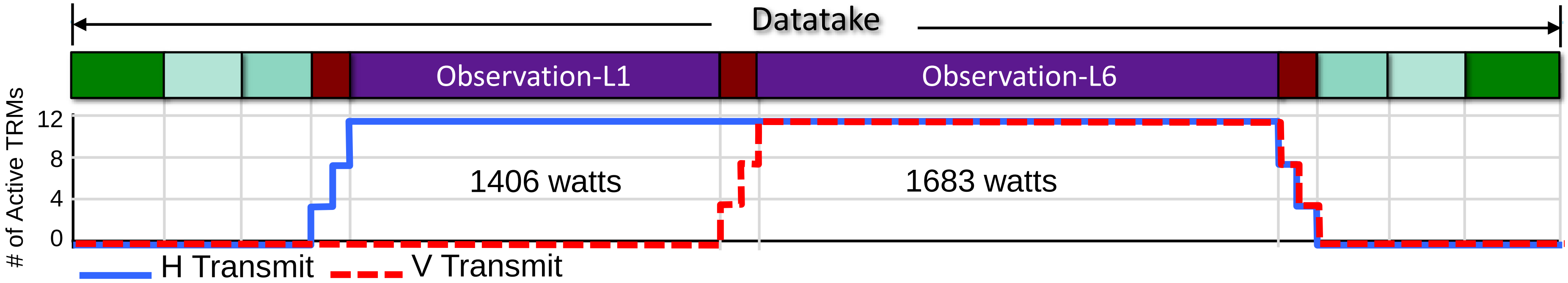
# How the L- and S-band radars coordinate observations

- The L-band and S-band radars uses a set of upload-able tables to control radar operations
- Consecutive ***Observations*** with the same start time are grouped into a ***Datatake*** and collected back-to-back with seamless transitions between them
- Each Datatake has a Pre- and Post-take for calibration and at least one or more observations



# How the L- and S-band radars coordinate timing

- **Joint Data Take Timing Synchronization**
  - To avoid mutual interference during joint operations, transmit events are synchronized
  - S-SAR uses the L-SAR STALO and timing signals to derive its pulse timing signals
- **Datatake Power Sequencing**
  - Because of power system constraints, the transitions from idle to transmit and transmit to idle must be sequenced on to prevent transients on the bus
  - S-SAR also does power sequence, but offset from L-SAR to minimize transients on the power bus

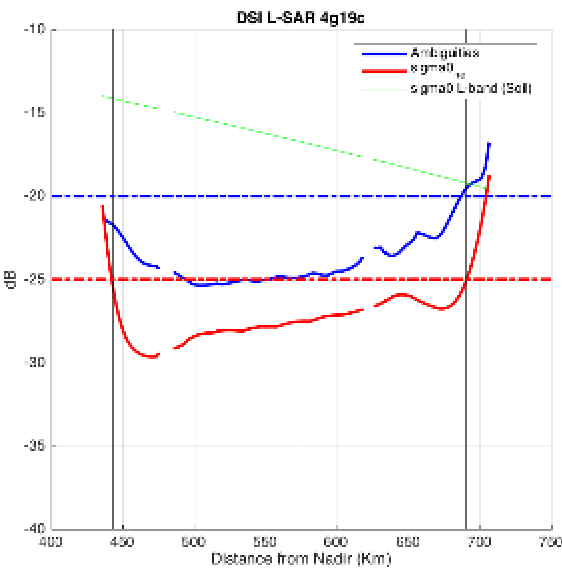


# Radar Modes

| | | Science | | | Performance | | | | Resources | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Config. ID | Old Mode # | Primary Science Target | Freq Band | Polarization | BW (MHz) | PRF (Hz) | PW [μσεχ] | Swath [km] | L-SAR DC [W]+ | S-SAR DC [W]# | L-Data Rate [Mbps] | S-Data Rate [Mbps]# |
| 0 | | Idle | - | - | - | - | - | - | 1200 | 728 | - | -1033.1 |
| 64 | S1 | Solid Earth/Ice/Veg/Coast/Bathym | S | Quasi-Quad | 37.5 | 2200 | 10+10 | 244 | 1200 | 1604 | - | 3714 |
| 65 | S2 | Ecosystem/Coastal Ocean/Cryosphere | S | DP HH/HV | 10 | 2200 | 25 | 244 | 1200 | 1836 | - | 626 |
| 66 | S3 | Agriculture/Sea Ice | S | CP RH/RV | 25 | 2200 | 25 | 244 | 1200 | 3020 | - | 1242 |
| 67 | S4 | Glacial Ice-High Res | S | CP RH/RV | 37.5 | 2200 | 25 | 244 | 1200 | 3020 | - | 1857 |
| 68 | SX | New mode | S | DP HH/HV | 37.5 | 2200 | 25 | 244 | 1200 | 3020 | - | 1857 |
| 69 | S5 | Deformation | S | SP HH (or SP VV) | 25 | 2200 | 25 | 244 | 1200 | 1563 | - | 620 |
| 70 | S6 | Deformation-Max Res | S | SP HH (or SP VV) | 75 | 2200 | 25 | 244 | 1200 | 1563 | - | 1857 |
| 128 | L1 | Background Land | L | DP HH/HV | 20+5 | 1650 | 25 | 242 | 1446.4 | 728 | 892.47 | - |
| 129 | | Background Land Soil Moisture | L | QQ | 20+5 | 1650 | 25 | 242 | 1446.6 | 728 | 892.47 | - |
| 130 | | Background Land Soil Moisture Hi Pwr | L | QQ | 20+5 | 1650 | 20 | 242 | 1519.3 | 728 | 888.39 | - |
| 131 | L2 | Land Ice | L | SP HH | 80 | 1650 | 40 | 121 | 1456.4 | 728 | 705.82 | - |
| 132 | | Land Ice Low Res | L | SP HH | 40+5 | 1650 | 45 | 242 | 1480.6 | 728 | 813.49 | - |
| 133 | | Low Data Rate Study Mode SinglePol | L | SP HH | 20+5 | 1650 | 25 | 242 | 1383.7 | 728 | 446.24 | - |
| 134 | L3 | Sea Ice Dynamics | L | SP VV | 5 | 1600 | 25 | 242 | 1380 | 728 | 90.84 | - |
| 135 | | Open Ocean | L | QD HH/VV | 5+5 | 1650 | 20 | 242 | 1519.3 | 728 | 186.55 | - |
| 136 | L4 | India Land Characterization | L | DP VV/VH | 20+5 | 1650 | 25 | 242 | 1446.4 | 728 | 892.47 | |
| 137 | L5 | Urban Areas, Himalayas | L | DP HH/HV | 40+5 | 1650 | 45 | 242 | 1543.4 | 728 | 1626.98 | - |
| 138 | | Urban Areas, Himalayas SM | L | QQ | 40+5 | 1650 | 45 | 242 | 1543.5 | 728 | 1626.98 | - |
| 139 | | Urban Areas, Himalayas SM Hi Pwr | L | QQ | 40+5 | 1650 | 40 | 242 | 1713.1 | 728 | 1619.63 | - |
| 140 | L6 | US Agriculture, India Agriculture | L | QP HH/HV/VH/VV | 40+5 | 1600* | 45 | 242 | 1748.4 | 728 | 3155.36 | - |
| 141 | LX | US Agriculture, India Agriculture Low Res | L | QP HH/HV/VH/VV | 20+5 | 1600* | 45 | 242 | 1748.4 | 728 | 1762.54 | - |
| 142 | L7 | Experimental CP mode | L | CP RH/RV | 20+20 | 1650 | 40 | 242 | 1519.3 | 728 | 712.93 | - |
| 143 | L8 | Experimental QQ mode | L | QQ | 20+20 | 1650 | 20 | 242 | 1519.3 | 728 | 1414.77 | - |
| 144 | L9 | Experimental SP mode | L | SP HH | 77 | 1650 | 20 | 242 | 1456.4 | 728 | 1435.36 | - |
| 145 | | ISRO Ice/sea-ice | L | DP VV/VH | 5 | 1650 | 25 | 242 | 1446.4 | 728 | 187.36 | - |
| 146 | | ISRO Ice/sea-ice - alternate | L | QD HH/VV | 5 | 1650 | 25 | 242 | 1567.7 | 728 | 187.36 | - |
| 192 | L1+S3 | Systematic Coverage | L+S | DP HH/HV<br>CP RH/RV | 20+5<br>25 | 1910^ | 25<br>25 | 242<br>244 | 1466 | 2752 | 1033.1 | |
| 193 | L1+S4 | Systematic Coverage & Deformation | L+S | DP HH/HV<br>DP HH/HV | 20+5<br>37.5 | 1910^ | 25<br>25 | 242<br>244 | 1466 | 1828 | 1033.1 | |
| 194 | L1+S5 | Coastal-Mudbank (wet soil ????) | L+S | DP HH/HV<br>SP HH (or SP VV) | 20+5<br>25 | 1910^ | 25<br>25 | 242<br>244 | 1466 | 1700 | 1033.1 | |
| 195 | L3+S2 | Ocean | L+S | SP VV<br>DP VV/VH | 5<br>10 | 1910^ | 25<br>25 | 242<br>244 | 1403 | 1828 | 108.44 | |
| 196 | L4+S3 | Sea Ice Types | L+S | L: DP VV/VH<br>S: CP RH/RV | 20+5<br>25 | 1910^ | 25^<br>25 | 242<br>244 | 1466 | 2710 | 1033.1 | 1078 |
| 197 | L5+S4 | Glacial Ice-Himalayas | L+S | L: DP HH/HV<br>S: CP/RH/RV | 40+5<br>37.5 | 1910^ | 45^<br>25 | 242<br>244 | 1578 | 2710 | 1883.36 | 1616 |
| 198 | L5+S6 | High-Res Deformation(Disaster/Urgent Response) | L+S | L: DP HH/HV<br>S: SP HH (or SP VV) | 40+5<br>75 | 1910^ | 45^<br>25 | 242<br>244 | 1578 | 1407 | 1883.36 | 1610 |
| 199 | L6+S3 | India Agriculture | L+S | L: QP HH/HV/VH/VV<br>S: CP RH/RV | 40+5<br>25 | 1550*^<br>3100 | 45^<br>10' | 242<br>244 | 1735 | 1990 | 3056.76 | 1754 |
| 200 | L6+SX | Coastal - Land | L+S | L: QP HH/HV/VH/VV<br>S: DP HH/HV | 40+5<br>37.5 | 1550*^<br>3100 | 45^<br>10' | 242<br>244 | 1735 | 1504 | 3056.76 | |
| 201 | LX+S3 | Coastal - X | L+S | L: QP HH/HV/VH/VV<br>S: CP HH/HV | 20+5<br>25 | 1550*^<br>3100 | 45^<br>10' | 242<br>244 | 1735 | 2104 | 1707.46 | |
| 202 | LX+SX | Coastal - X | L+S | L: QP HH/HV/VH/VV<br>S: DP HH/HV | 20+5 | 1550*^<br>3100 | 45^<br>10' | 242<br>244 | 1735 | 1504 | 1707.46 | |
| 203 | L?+S3 | ISRO Ice/sea-ice | L+S | DP VV/VH<br>CP RH/RV | 5<br>25 | 1910^ | 25<br>25 | 242<br>244 | 1466 | 2752 | 216.89 | |
| 204 | L?+S2 | ISRO Ice/sea-ice - Jjoint Alternate | L+S | DP VV/VH<br>DP VV/VH | 5<br>10 | 1910^ | 25<br>25 | 242<br>244 | 1466 | 1828 | 216.89 | |
| 205 | L2+S3 | Antarctic | L+S | SP HH<br>CP RH/RV | 77<br>25 | 1910^ | 40<br>25 | 242<br>244 | 1487 | 2752 | 817.04 | |

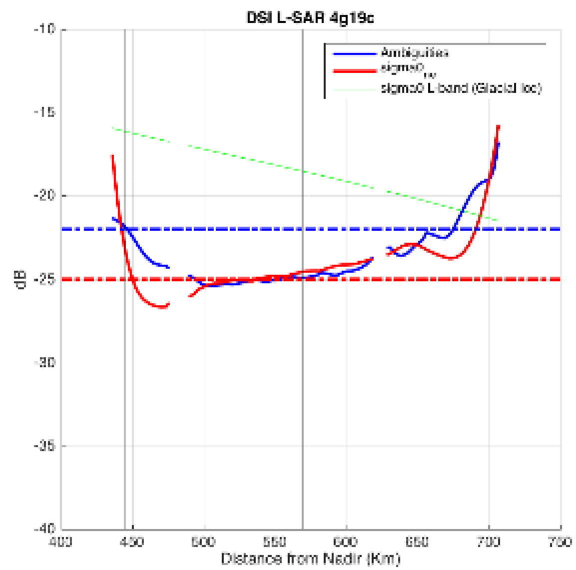
# Example NES0 and Ambiguity Performance

## Mode L1



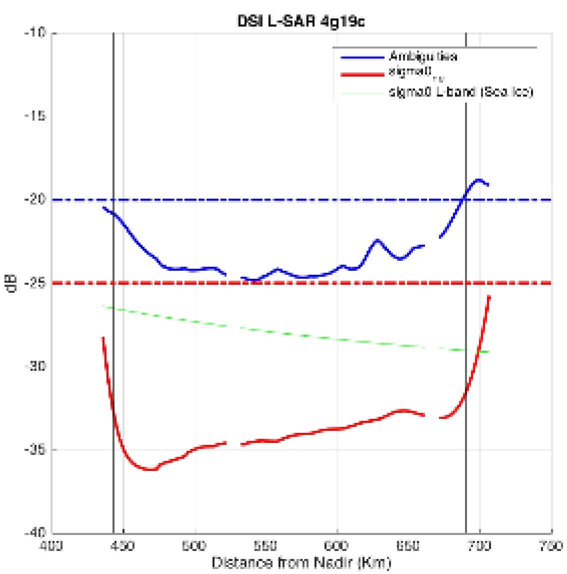

| DSI L-SAR 4g19c | 14-Mar-2016 |
|---|---|
| Dual Pol | HH |
| Altitude | 765 km |
| Repeat Period | 12 days |
| Ant Diam | 12.0 m |
| F/D | 0.75 |
| N Beams | 12 |
| FRAp El Spc | 18.00 cm |
| FRAp Az Spc | 13.00 cm |
| Frequency | 1257.5 MHz |
| Mech Boresight | 37.0 Deg |
| Tx Power | 1404 W |
| Tsys | 657.2 K |
| Tx Loss | -1.01 dB |
| Rx Loss | -1.01 dB |
| PRF per Pol | 1650 Hz |
| Proc BW | 1100 Hz |
| Bandwidth | 20.0 MHz |
| Total Bandwidth | 25.0 MHz |
| Pulse Width | 20.0 usec |
| Total Pulse width | 25.0 usec |
| N Taps | 3 |
| NES0 Threshold | -25 dB |
| Ambiguity Threshold | -20 dB |
| Required Swath | 242 km |
| Swath | 242.2219 km |
| Swath Avg NESZ | -27.4724 dB |
| Swath Avg Amb | -23.7743 dB |
| Inc Ang (near) | 33.95 Deg |
| Inc Ang (far) | 47.04 Deg |
| Look Ang (near) | 29.96 Deg |
| Look Ang (far) | 40.87 Deg |
| Bits per Sample | 4 |
| Data Rate | 592.47 Mbps |

## Mode L2



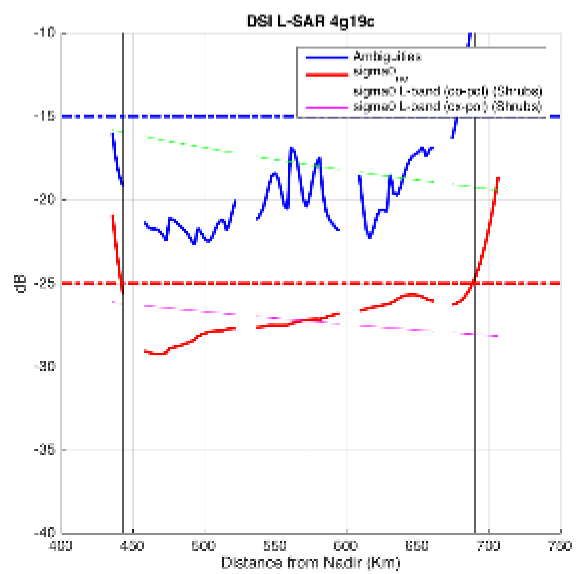

| DSI L-SAR 4g19c | 14-Mar-2016 |
|---|---|
| Single Pol | HH |
| Altitude | 765 km |
| Repeat Period | 12 days |
| Ant Diam | 12.0 m |
| F/D | 0.75 |
| N Beams | 12 |
| FRAp El Spc | 18.00 cm |
| FRAp Az Spc | 13.00 cm |
| Frequency | 1257.5 MHz |
| Mech Boresight | 37.0 Deg |
| Tx Power | 1404 W |
| Tsys | 657.2 K |
| Tx Loss | -1.01 dB |
| Rx Loss | -1.01 dB |
| PRF per Pol | 1650 Hz |
| Proc BW | 1100 Hz |
| Bandwidth | 80.0 MHz |
| Total Bandwidth | 80.0 MHz |
| Pulse Width | 40.0 usec |
| Total Pulse width | 40.0 usec |
| N Taps | 3 |
| NES0 Threshold | -25 dB |
| Ambiguity Threshold | -22 dB |
| Required Swath | 121 km |
| Swath | 121.5688 km |
| Swath Avg NESZ | -25.2788 dB |
| Swath Avg Amb | -24.4031 dB |
| Inc Ang (near) | 34.10 Deg |
| Inc Ang (far) | 41.15 Deg |
| Look Ang (near) | 30.09 Deg |
| Look Ang (far) | 36.04 Deg |
| Bits per Sample | 4 |
| Data Rate | 705.82 Mbps |

## Mode L3



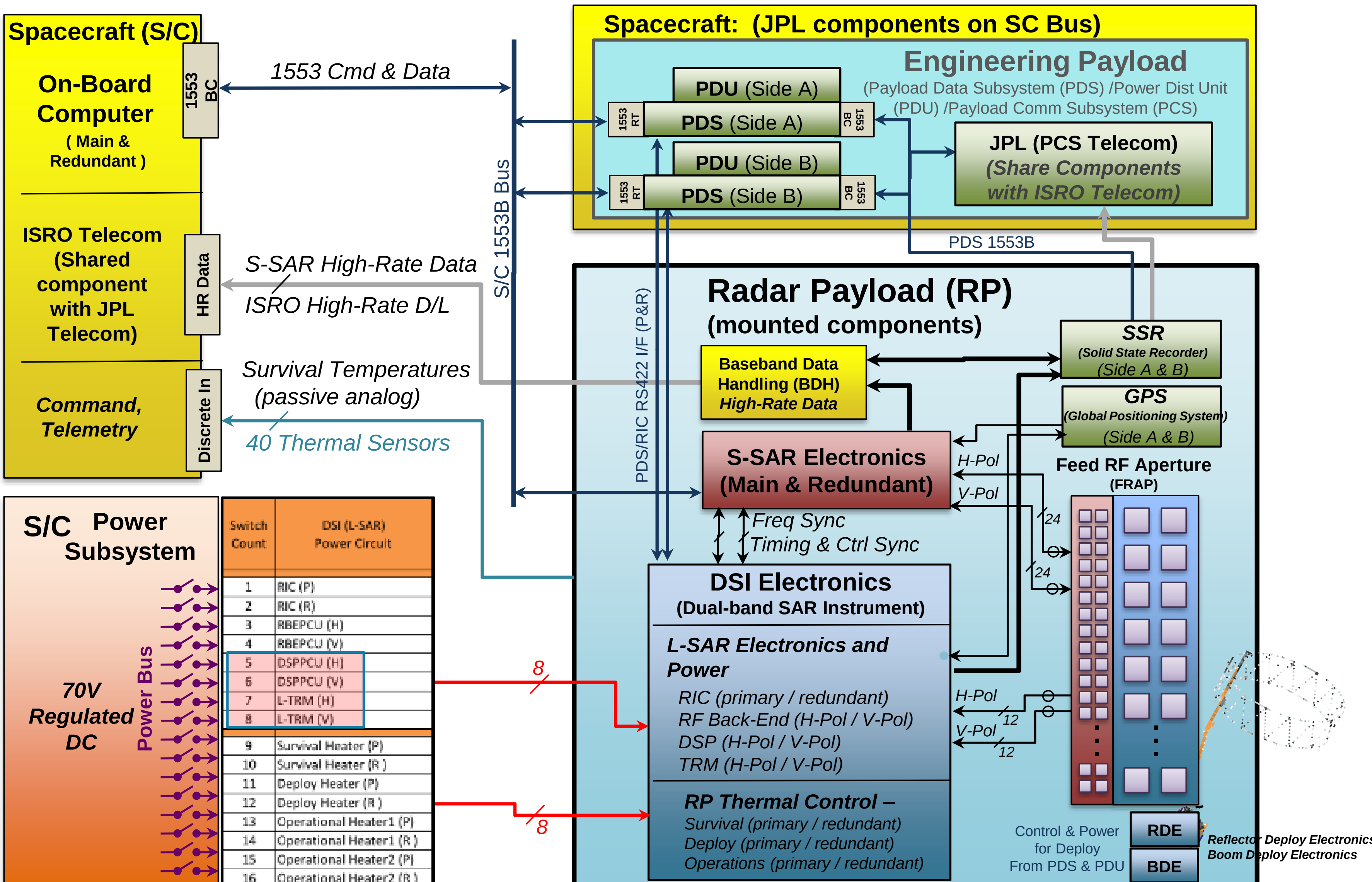

| DSI L-SAR 4g19c | 14-Mar-2016 |
|---|---|
| Single Pol | VV |
| Altitude | 765 km |
| Repeat Period | 12 days |
| Ant Diam | 12.0 m |
| F/D | 0.75 |
| N Beams | 12 |
| FRAp El Spc | 18.00 cm |
| FRAp Az Spc | 13.00 cm |
| Frequency | 1257.5 MHz |
| Mech Boresight | 37.0 Deg |
| Tx Power | 1404 W |
| Tsys | 657.2 K |
| Tx Loss | -1.28 dB |
| Rx Loss | -1.28 dB |
| PRF per Pol | 1600 Hz |
| Proc BW | 1100 Hz |
| Bandwidth | 5.0 MHz |
| Total Bandwidth | 5.0 MHz |
| Pulse Width | 25.0 usec |
| Total Pulse width | 25.0 usec |
| N Taps | 3 |
| NES0 Threshold | -25 dB |
| Ambiguity Threshold | -20 dB |
| Required Swath | 242 km |
| Swath | 242.2219 km |
| Swath Avg NESZ | -34.1079 dB |
| Swath Avg Amb | -23.3845 dB |
| Inc Ang (near) | 33.95 Deg |
| Inc Ang (far) | 47.04 Deg |
| Look Ang (near) | 29.96 Deg |
| Look Ang (far) | 40.87 Deg |
| Bits per Sample | 4 |
| Data Rate | 90.84 Mbps |

## Mode L6




| DSI L-SAR 4g19c | 14-Mar-2016 |
|---|---|
| Quad Pol | VH |
| Altitude | 765 km |
| Repeat Period | 12 days |
| Ant Diam | 12.0 m |
| F/D | 0.75 |
| N Beams | 12 |
| FRAp El Spc | 18.00 cm |
| FRAp Az Spc | 13.00 cm |
| Frequency | 1257.5 MHz |
| Mech Boresight | 37.0 Deg |
| Tx Power | 1404 W |
| Tsys | 657.2 K |
| Tx Loss | -1.28 dB |
| Rx Loss | -1.01 dB |
| PRF per Pol | 1600 Hz |
| Proc BW | 1100 Hz |
| Bandwidth | 40.0 MHz |
| Total Bandwidth | 45.0 MHz |
| Pulse Width | 40.0 usec |
| Total Pulse width | 45.0 usec |
| N Taps | 3 |
| NES0 Threshold | -25 dB |
| Ambiguity Threshold | -15 dB |
| Required Swath | 242 km |
| Swath | 242.2219 km |
| Swath Avg NESZ | -27.1558 dB |
| Swath Avg Amb | -18.3251 dB |
| Inc Ang (near) | 33.95 Deg |
| Inc Ang (far) | 47.04 Deg |
| Look Ang (near) | 29.96 Deg |
| Look Ang (far) | 40.87 Deg |
| Bits per Sample | 4 |
| Data Rate | 3155.35 Mbps |

# External Spacecraft Interfaces

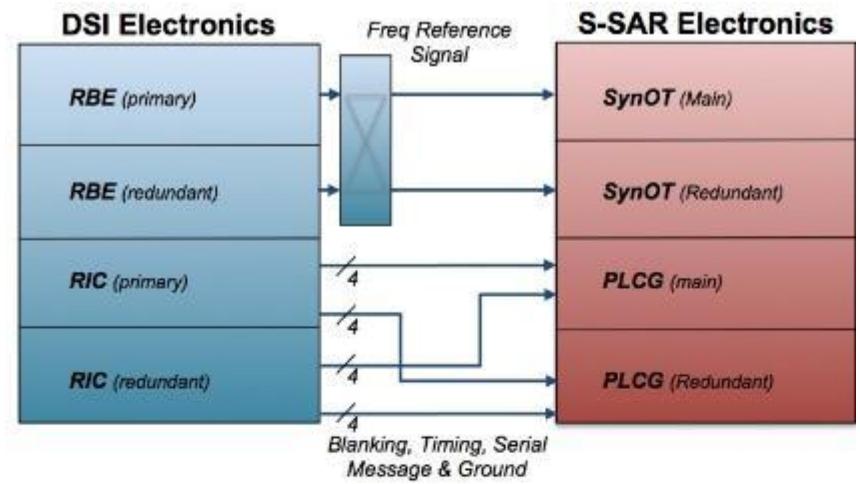



| Switch Count | DSI (L-SAR) Power Circuit |
|---|---|
| 1 | RIC (P) |
| 2 | RIC (R) |
| 3 | RBEPCU (H) |
| 4 | RBEPCU (V) |
| 5 | DSPPCU (H) |
| 6 | DSPPCU (V) |
| 7 | L-TRM (H) |
| 8 | L-TRM (V) |
| 9 | Survival Heater (P) |
| 10 | Survival Heater (R ) |
| 11 | Deploy Heater (P) |
| 12 | Deploy Heater (R ) |
| 13 | Operational Heater1 (P) |
| 14 | Operational Heater1 (R ) |
| 15 | Operational Heater2 (P) |
| 16 | Operational Heater2 (R ) |

# L-SAR / S-SAR electrical interfaces

- To ensure proper timing during joint radar operations, four signals are generated by the L-SAR radar electronics and provided to S-SAR. These signals consist of:
  - **Frequency Reference**: 10 MHz StaLO RF signal to derive timing signals (50ohm coax)
  - **Global Blanking Pulse**: Pulsed RS422 signal to synchronize transmit events
  - **Radar Timing Reference**: Pulsed RS422 to serve as a precise time marker
  - **Radar Serial Message**: Asynchronous serial message containing radar mode, L-SAR clock time, L-SAR pulse count, GPS time and position, etc.

- S-SAR uses L-SAR StaLO and timing signals to derive its pulse timing signals for any Datatake that contains at least one joint observation
- No faults can propagate from S-SAR to L-SAR



# Progress in L-band SAR Electronics Engineering Model (EM) Hardware Development


EM Waveform Generator (WG)

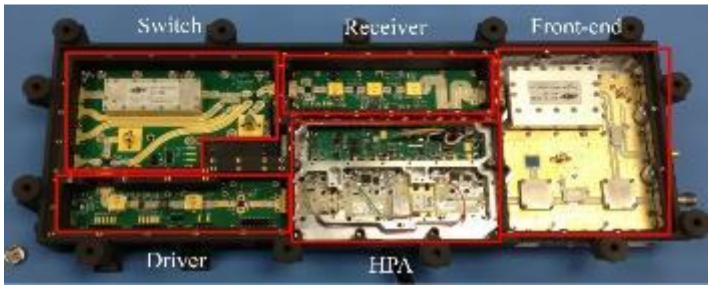

EM Up Converter Driver (UCD)


EM Frequency Synthesizer (FS)


EM RBE-PCU
(Power Cond Unit)

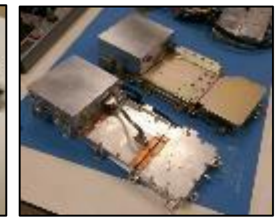

EM RF Back-End (RBE) Stack


EM TRM-ESS
(Energy Storage Subassembly)



TRM Pathfinder EM


EM Front-End Subassembly (FES)


Early JPL Prototype TRM
(1st Generation)

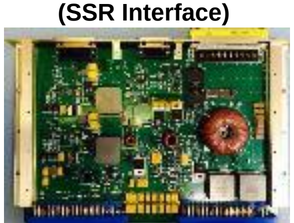

Boeing TRM EM
(2nd Generation)


EM RIC-CTB
(Control & Timing Board)


EM RIC-SIF
(SSR Interface)


RIC- RAD750 Qual Model
(Single Board Computer)


EM RIC-HKT
(Housekeeping Telemetry)


EM RIC-PCU
(Power Conditioning Unit)


FM RIC-NVM (SEAKR)
(Non-Volatile Memory)

## Digital Signal Processor (DSP)


EM DSP-PCU
(Power Cond Unit)


EM QFSP
(Quad First Stage Processor)


EM SSP
(Second Stage Processor)

# L-SAR Electronics Status

TRM EM

RBE EM stack

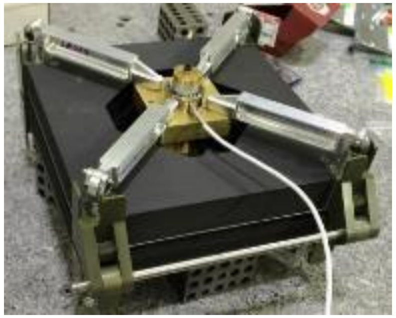
QFSP EM

RIC EM

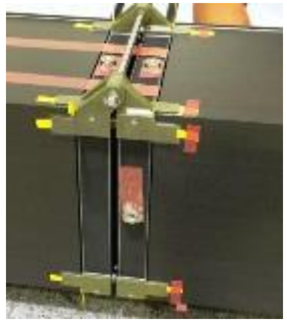
- <u>Transmit/Receive Module (TRM)</u>
  - Boeing is on contract to develop the NISAR TRMs and has built two EM TRM assemblies
  - Critical Design Review (CDR) scheduled for January 2018; Flight build (30 units) will start in February, 2018
  - <u>Key Challenges</u>: Phase stability, on-board calibration, unit-to-unit variability
- <u>RF Back-End (RBE)</u>
  - RBE EM (WG, FS, UCD, RBE-PCU) was built and tested
  - CDR was completed in August 2017; Flight build is now underway
  - <u>Key Challenges</u>: Phase stability, split spectrum, spectrum compliance
- <u>Digital Electronics Subsystem (DES)</u>
  - Completed Digital Signal Processor (DSP) EM development (QFSP, SSP, DSP-PCU)
  - Completed Radar Instrument Controller (RIC) EM development (SBC, NVM, CTB, HKT, SIF)
  - DES CDR was completed in October 2017; flight build is now underway
  - <u>Key Challenges</u>: SweepSAR timing, PRF dithering, seamless transitions, on-board filtering and data compression
- <u>L-SAR EM I&T:</u>
  - L-SAR Interface testing completed, including L-SAR/S-SAR interface test
  - End-to-end test performance is on-going
  - <u>Key Challenges</u>: End-to-End phase stability, digital beamforming, joint L-SAR/S-SAR data take timing synchronization, power sequencing

# Progress in Antenna Hardware Development

## Boom and Hinge Development Hardware



*10" Development Boom Stability Test*

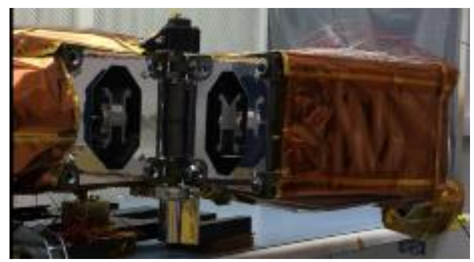


*7" Prototype Boom/Hinge in fabrication*

## Boom Hinge Deploy & Latching Hardware

*PT Spring Assemblies*

*Boom Actuator PT*

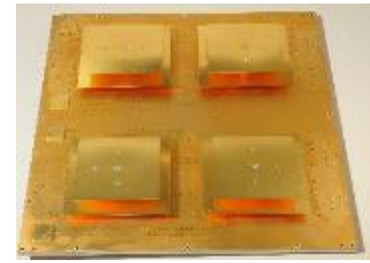


*Prototype 7" Spring/Damper Deploy Test*

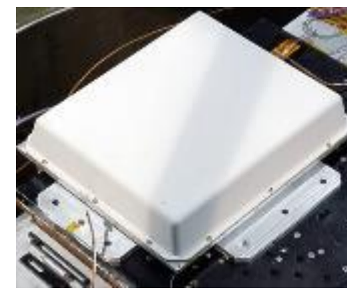
*Hinge Spring Cartridge Torque Test*

*Boom Harness Torque Test*

## L-FRAP Feed Tile Development Hardware



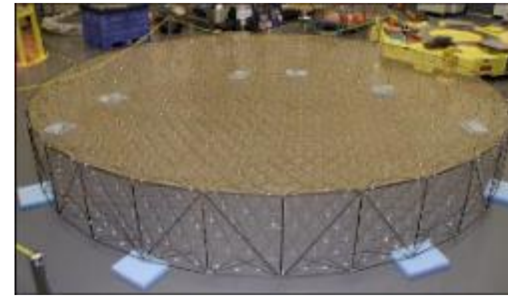
*Feed Tile EM (without radome)*



*Feed Tile EM (with radome)*

*Feed Array EM in Test*

# Radar Antenna Reflector and Boom Status

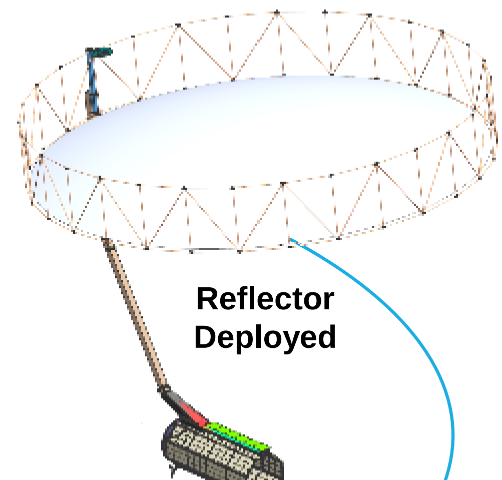


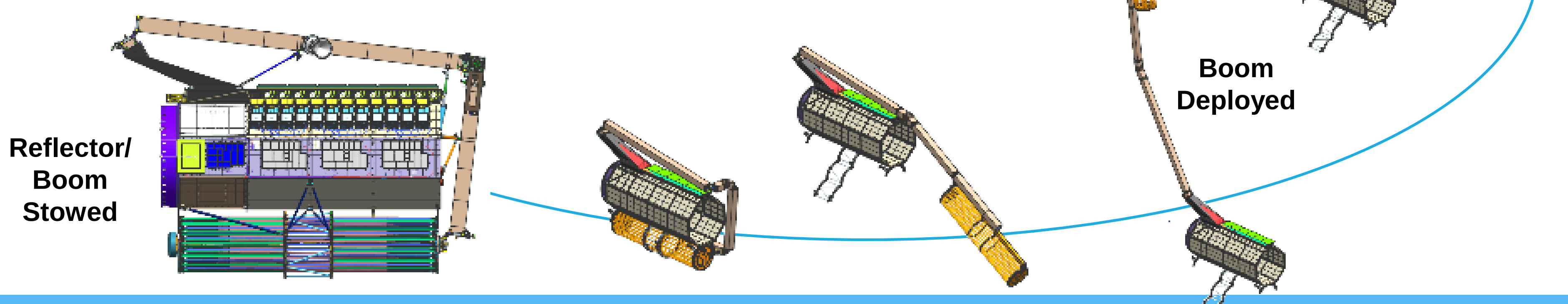
## Radar Antenna Reflector (RAR)

- Northrop Grumman-Astro Aerospace is providing the 12-m AstroMesh (AM-1) Perimeter Truss mesh reflector
- AM-1 heritage was confirmed for reflector; minor modifications to launch restraints required
- CDR completed in October 2017; flight build to start in Jan 2018
- Key Challenges: Launch and deployment loads, maintaining reflector heritage/minimizing design change, pointing stability

## Radar Antenna Boom (RAB)

- Orbital-ATK is providing the composite boom/hinge for the 4-hinge, spring damper design; JPL provides launch restraints
- Key Challenges: Launch and deployment loads, thermal stability, hinge torque margin, low mass



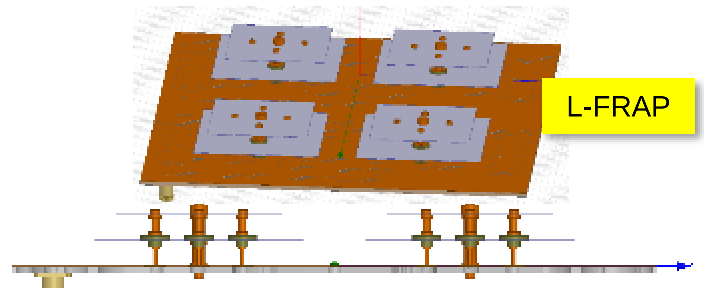
# Antenna Feed and Structure Status

## Antenna Feed

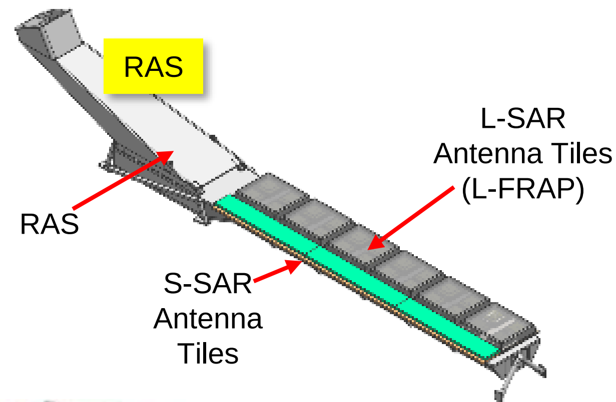
- Built and tested the L-band Feed Aperture (L-FRAP) EM array (6 tiles)
- Completed L-FRAP/S-FRAP antenna coupling test
- Completed EM feed tile qualification testing (multipaction, thermal-vac, random vibration, acoustic)
- CDR is scheduled for January 2018; Flight build to start in February 2018
- Key Challenges: High power RF breakdown/ multipaction, phase stability, pointing stability

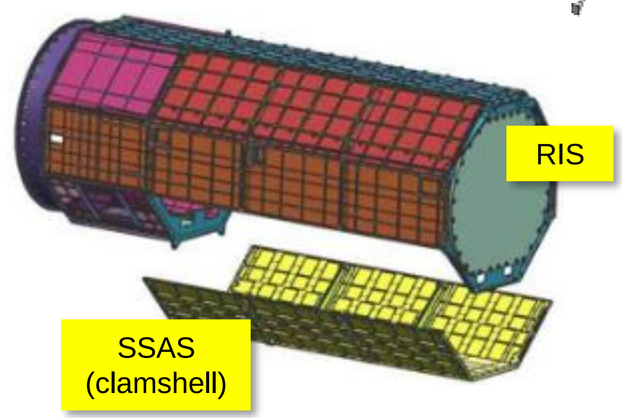
## Radar Instrument Structure

- Matured the mechanical, thermal and cabling design, configuration and accommodations with ISRO
- Released all mechanical interface drawings
- CDR completed in August 2017; flight structure fabrication to start in January 2017
- Key Challenges: Complex interface with S-SAR, thermal design for joint L-SAR/S-SAR operations and left/right looking operation




**Stacked-patch, air-dielectric tile design**



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